Comments on Warm Events in the Southern Oscillation and Local Rainfall over Southern Asia

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25 October 1985 and 11 January 1986

ABSTRACT

In a narrow belt across southern Asia stretching from central India to the Philippines there seems to be no unique association between rainfall and Warm Events in the Southern Oscillation. In this area there are marked long term trends in the rainfall, and the Warm Events are inclined to fall in wet years when the period is generally wet and in dry years when the period is generally dry.

1. Introduction

It has long been known (see, for instance, Chart 10 in Walker and Bliss, 1932) that the rainfall over much, *but not all,* of southern Asia tends to be below normal in summer during a Warm Event (WE) in the Southern Oscillation (SO). There are, e.g., statistically significant relationships between the SO and the *areally averaged* rainfall over India (Rasmusson and Carpenter, 1983; Bhalme and Jadhav, 1984). But, as we point out in this note, there may be limited regions in southern Asia where there is no unique association between the rainfall in June–August and the state of the SO.

We examine below several times series of rainfall anomalies at stations in southern Asia from 1900 to 1983 to see how the relationship with the Warm Events varied locally during the period. There were 19 Warm Events in the 84 years, of which ten fell during the former and nine during the latter half. Although several lasted more than one calendar year, such as 1939–41, 1957/58, and 1976/77, we shall deal only with Year_0, that is, the year when the warming began in the equatorial Pacific.

The mean anomalies of sea level pressure in Warm Events in June–August appear in Fig. 1. We compiled this map in the following way: the mean against which the anomalies are measured consists of all summers which were not a Year_0 in a Warm or a Cold Event (van Loon and Shea, 1985, contains a list of the events). Grid point data for 50 such years were available north of 20°N, and for 23 years between the equator and 20°N. The anomalies are for 19 WEs north of 20°N and for nine events to the south. The results of a Student's t test of Fig. 1 are shown in Fig. 2. The anomalies are nearly everywhere below one millibar, but because of the small interannual variability they are statistically significant beyond the 95% confidence level not only in the North Pacific Ocean where negative anomalies extend across the equator from the South Pacific Ocean, but also in the belt of positive anomalies across our area of interest from the Philippines to India. The axis of these positive anomalies lies along the zone of strongest convection as defined by outgoing longwave radiation. The direction of the geostrophic mean anomaly winds for WEs appears as arrows in Fig. 1.

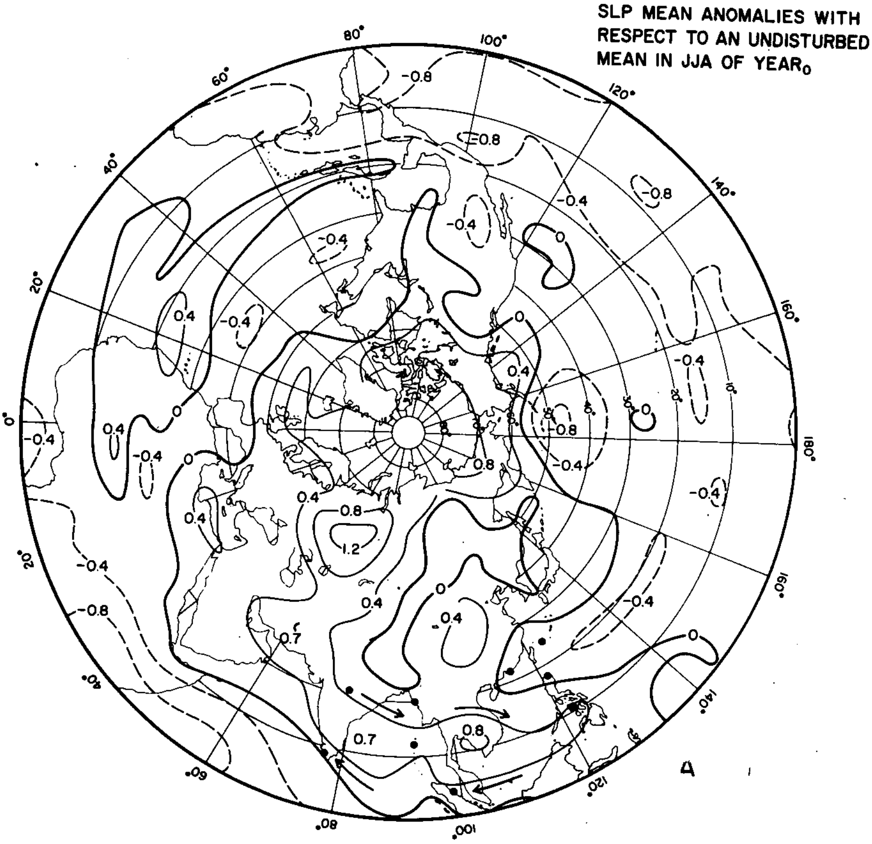
The sample is considerably larger north than south of 20°N and one might therefore have expected slightly different patterns on either side of 20°N; however, no difference was detected, perhaps because of the comparatively coarse grid of 5° latitude by 5° longitude.

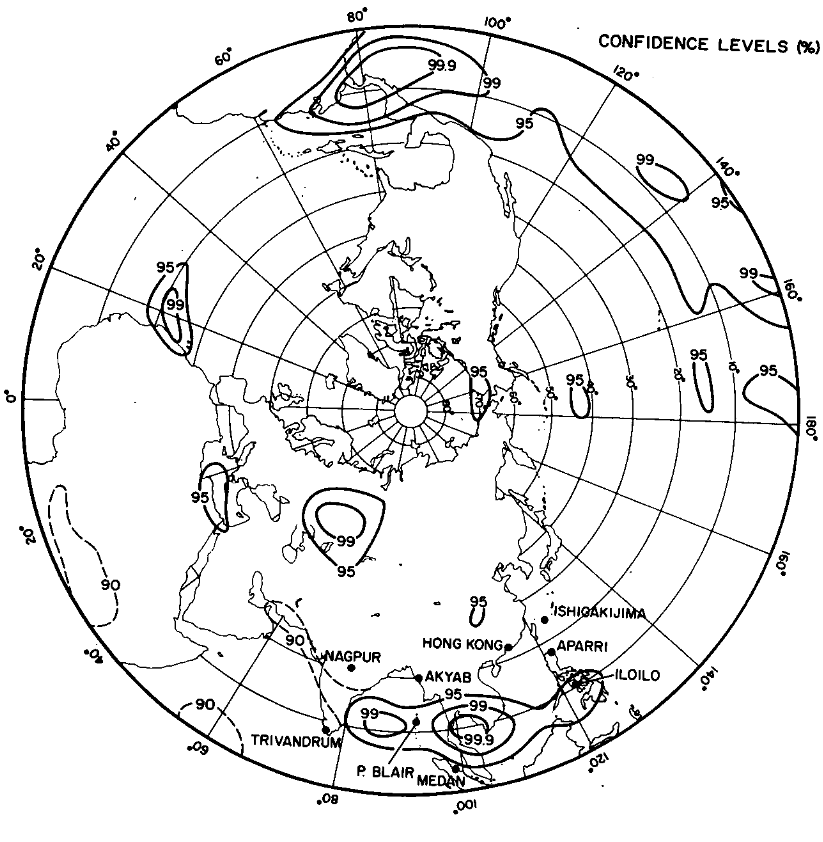
2. The rainfall anomalies

We are aware that the rainfall at a single station in a given year is not necessarily representative of a large region, but as we are describing changes over a long period, the objection to using single stations cannot be so strong as it would be if we had worked with only one year.

Beginning with Nagpur (Fig. 3a; the positions are given in Fig. 2), we note that the rainfall was generally lower during the second than during the first half of the period. Fifteen of the 19 WEs fell during years of negative anomalies, and for the period as a whole it is

* The National Center for Atmospheric Research is sponsored by the National Science Foundation.


SLP MEAN ANOMALIES WITH RESPECT TO AN UNDISTURBED MEAN IN JJA OF YEAR$_0$


CONFIDENCE LEVELS (%)
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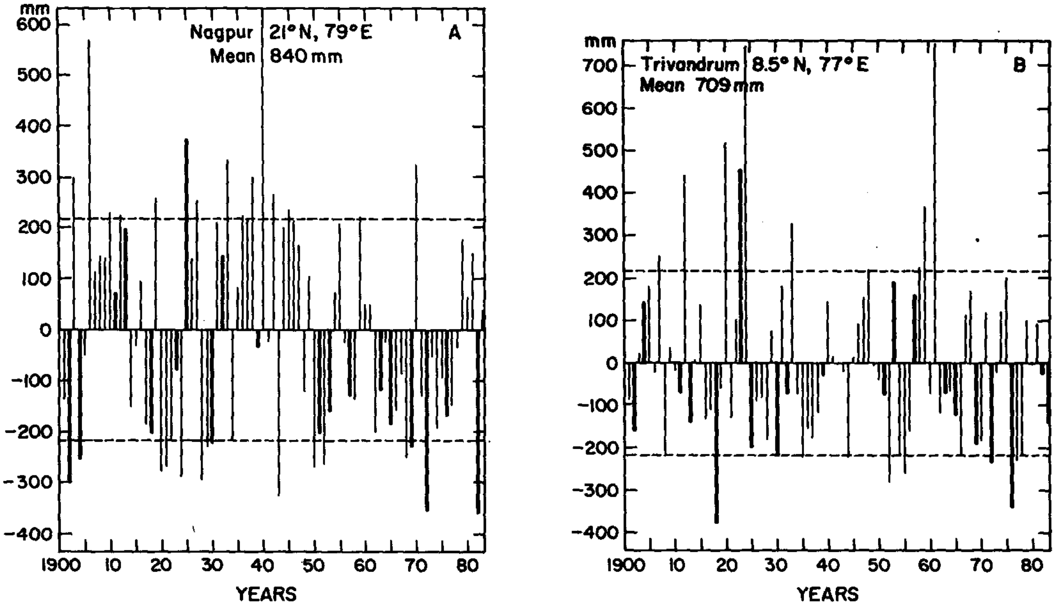


FIG. 3. (a) Rainfall anomalies (mm) in June–August for Nagpur. The dashed horizontal lines are one standard deviation below and above the mean. The accentuated vertical bars are Years_0 of Warm Events in the Southern Oscillation. Position is given in Fig. 2b. (b) As in (a), but for Trivandrum.

true that WEs tended to be associated with below normal rains. If only the first 50 years had been available, it is clear that the association between Warm Events and rain was not unique, as four out of ten of the Warm Events occurred during years with above normal rains. At Trivandrum in the south of India (Fig. 1b), where there is no obvious trend during the 84 years, both halves of the period show an equally marked tendency for the rains to be below normal in WEs, so that a correlation with the SO would in this respect be stable throughout the period.

Despite the missing years at Akyab (Fig. 4a), it appears that the circumstances there are similar to those at Nagpur: more Warm Events during years of above-normal rain during the first, wetter half of the period and more WEs during years of below-normal rain during the drier second half. Farther south, at Port Blair and Medan (Figs. 4b and 4c), where there is an upward trend of rainfall, we observe the opposite: the Warm Events in the first, drier half of the period tended to fall in years of below-normal rains whereas those in the second half were more numerous and had heavier rain during above normal years.

In the eastern part of our area, Iloilo (Fig. 5a) is similar to Nagpur and Akyab with a downward trend during which more WEs occurred during the wet than during the dry years before the Second World War and conversely in the dry years thereafter. In other words, a correlation between Warm Events in the SO and the rainfall would change sign from the first to the second half of the 84 years. Farther north in the Philippines, Aparri (Fig. 5b) shows the same state of affairs. Only four degrees farther north, at Hong Kong (Fig. 5c), there is no marked trend in the rainfall, and as 13 WEs happened during years with rains above normal and only 6 during years with below-normal rain, there is a tendency at this station for WEs to be associated with good rains throughout the period.

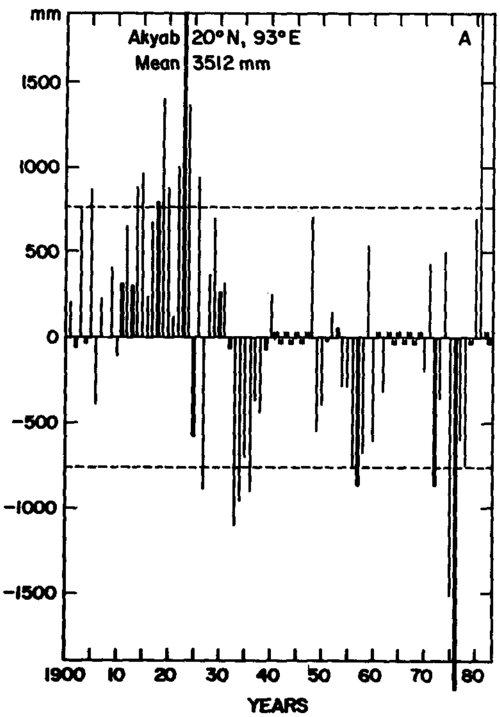
The last station, Ishigakijima (Fig. 5d) has no trend and no unique relation with the Warm Events.

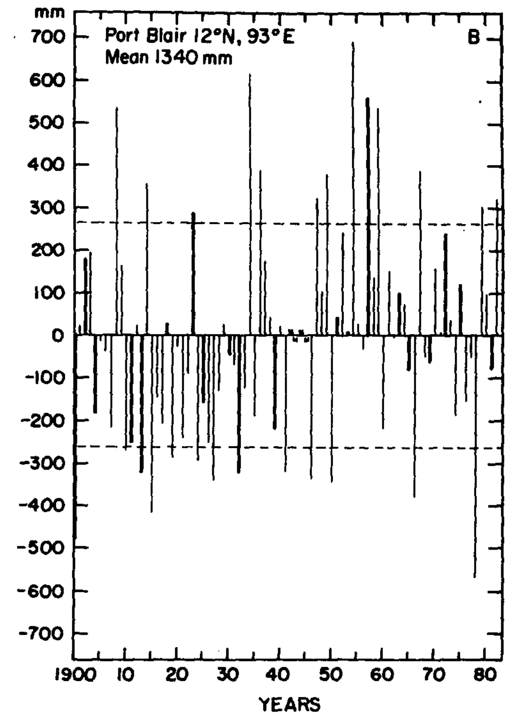
3. Conclusion

It appears from the preceding description that there are stations in southern Asia whose rainfall has no single relationship with the Warm Events in the Southern

FIG. 1. Sea level mean pressure anomalies (mb) in Year_0 of Warm Events for June–July–August. 19 Warm Events north of 20°N, 9 Warm Events to the south. The mean, which is without Warm and Cold Events, contains 50 years north of 20°N and 23 years to the south.

FIG. 2. Confidence levels of a Student's t test performed for Fig. 1.





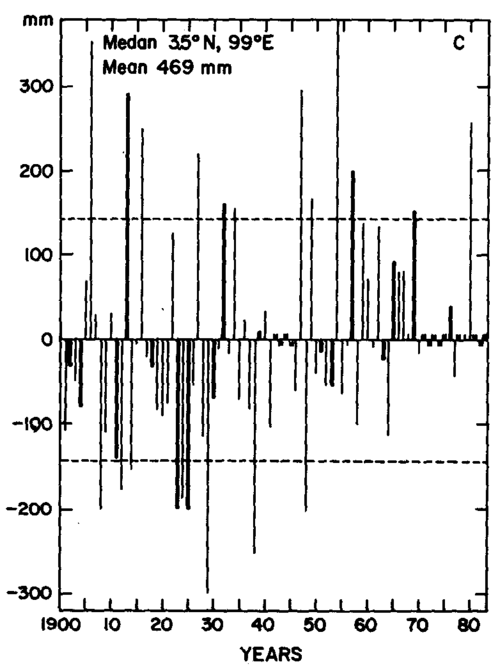


FIG. 4. As in Fig. 3 but (a) for Akyab, (b) for Port Blair, (c) for Medan.

Oscillation. Thus the size or sign of a correlation coefficient at such stations would change from one period to another. *These stations have in common a marked long-term trend in their rainfall, upward* ***or*** *downward, and the Warm Events are inclined to happen in wet years when the rains are above normal in the trend, and during dry years when the period is generally dry.* Stations with such marked trends seem to be located systematically with respect to the positive pressure anomalies associated with Warm Events (Fig. 1), but the scant pressure data leave this suggestion open to question.

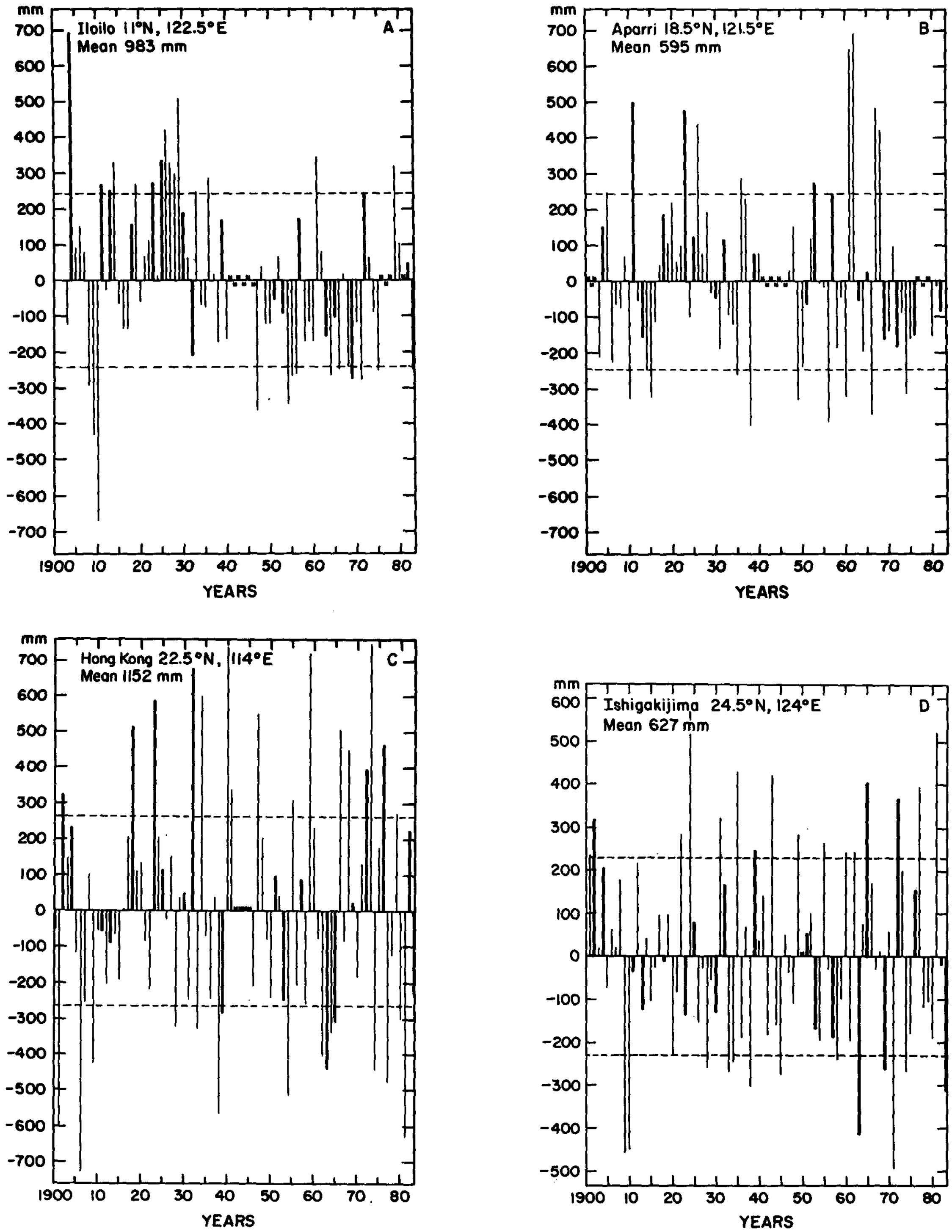


FIG. 5. As in Fig. 3, but (a) for Iloilo, (b) for Aparri, (c) for Hong Kong, and (d) for Ishigakijima.

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